660.51
S993

THE JOHN CRERAR
AUG 25 1947
LIBRARY

SYNTHETIC ORGANIC CHEMICALS

PUBLISHED BY

Eastman Kodak Company, Rochester 4, N. Y.

VOLUME 19 • 1947 • NUMBER 3

Azulenes

By JOE H. CLARK*

THE first observation that a substance having a blue color occurs in oil of camomile was reported in the fifteenth century. Since that time extensive studies have shown that this or similar blue coloring matters are constituents of about twenty per cent of the known essential oils. The isolation and determination of the structure of these substances has long defied the efforts of numerous chemists. Within the past decade Pfau and his collaborators have carried out investigations which have terminated in syntheses.

The substances secured from the oils, usually by a dehydrogenation procedure, have been named "azulenes" because of their deep blue or violet color. Many azulenes have been reported. Each was named for the oil from which it was isolated; e.g., guaiazulene from oil of guaiacum wood, camazulene from oil of camomile, eucazulene from eucalyptus oil, and gurjunazulene from gurjun balsam. A synthetic azulene was reported as a by-product in Reppe's work on cyclooctatetrene.

Little progress could be made in determining the structures of these compounds until a method for extracting them from the essential oils was devised. The discovery by Sherndal, in 1915, that the azulenes could be extracted from ether or ligroin solutions with concentrated phosphoric acid provided the needed tool. The material could then be recovered by dilution of the acid with water.

From the azulenes thus purified, crystalline picrates and styphnates were prepared. Analytical data from the purified azulenes and their derivatives showed them to be hydrocarbons with the molecular formula, $C_{15}H_{18}$, isomeric with alkyl naphthalenes having the same number of carbon atoms.

Hydrogenation studies showed the presence of five double bonds; molecular refraction and parachor calculations indicated the presence of two rings. Neither of the rings, however, was aromatic since oxidation of the azulenes themselves and their hydrogenated derivatives, either with ozone or with permanganate, gave only formic, acetic, and isobutyric acids and acetone. No derivatives of benzoic or phthalic acids were obtained.

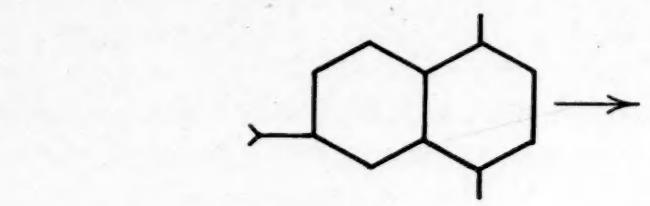
A number of unsatisfactory structures were proposed by various workers on the basis of these oxidation products and other rather equivocal evidence. These structures were disproved and another, later confirmed by synthesis, was proposed by Pfau and Plattner.

*Formerly Research Laboratories, Eastman Kodak Company; now with American Cyanamid Company, New York, N. Y.

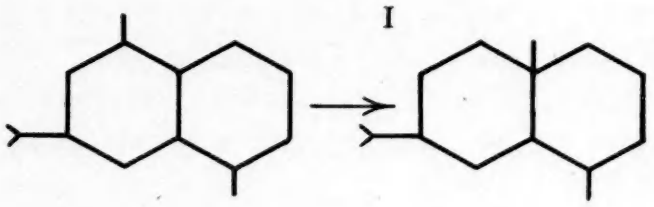
They first showed that many of the supposedly different azulenes reported in the literature were identical. This was facilitated by the discovery that the azulenes formed addition products with trinitrobenzene and trinitrotoluene which had much better crystalline properties and melting points than the picrates and styphnates. These addition products were decomposed by passing them, in methyl cyclohexane solution, through a column of activated alumina. The trinitro compound was adsorbed and the azulene could be recovered from the solvent in a very pure state.

Making use of the above derivatives, the known azulenes were narrowed to the following: S-guaiazulene, obtained by the dehydrogenation with sulfur of oil of guaiacum wood (the product obtained with selenium is a mixture), and also from the oils of callistris, patchouli, gurjun balsam, eucalyptus, and geranium; camazulene, from camomile and yarrow oils; lactarazulene, from the fungus, Lactarius deliciosus; elemazulene from oil of elemi; and vetivazulene from vetiver oil. The work of Pfau and Plattner was largely carried out with S-guaiazulene and vetivazulene.

When the sesquiterpene fractions of vetiver and guaiacum wood oils were dehydrogenated with red phosphorus



I



II III

and hydrogen iodide there were obtained, along with the expected azulenes, the naphthalenes, I (with S-guaiazulene) and II (with vetivazulene). The most obvious deduction from this fact was that the azulenes had the eudesmol skeleton III. This was excluded because the completely hydrogenated azulenes, on dehydrogenation, gave azulenes again while completely reduced compounds of the type III gave none.

The next information on the structure of the azulenes came from a study of β-vetivone, and a ketone with the formula $C_{15}H_{22}O$, isolated from oil of vetiver, and which yielded vetivazulene on dehydrogenation. Reduction of β-vetivone to tetrahydro-β-vetivol, followed by oxidation with chromic acid gave a small yield of a dibasic acid, along with tetrahydro-β-vetivone, the principal product. This acid, on treatment with barium hydroxide in acetic anhydride gave a ketone containing one less carbon atom than β-vetivone. This new ketone, on dehydrogenation, gave a phenolic compound. These reactions are represented in Figure 1.

DEGRADATION EXPERIMENTS

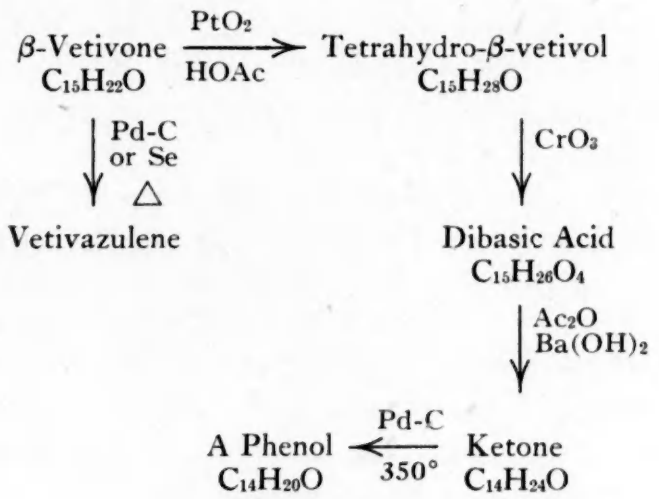
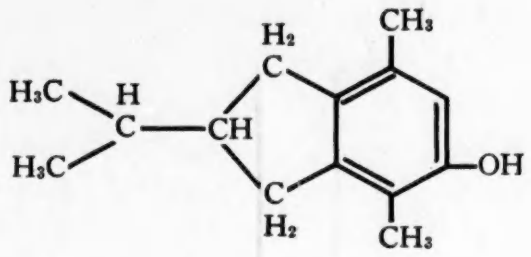


FIG. 1

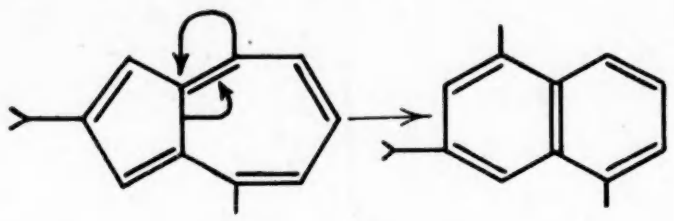
This series of reactions resulting in the loss of one carbon atom from the ring and the subsequent formation of a six-membered ring indicates the presence of a seven-membered ring in the original molecule. The phenol was shown by synthesis to be 2-isopropyl-4,7-dimethylindanol, IV.

Assuming that vetivazulene, like β-vetivone, has a seven- and a five-mem-

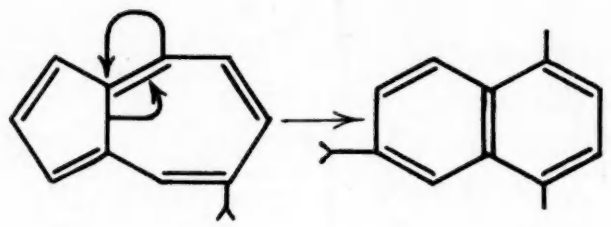


IV

bered ring and also taking into account the structure of IV, structure V was assigned to vetivazulene and VI tentatively to S-guaiazulene.



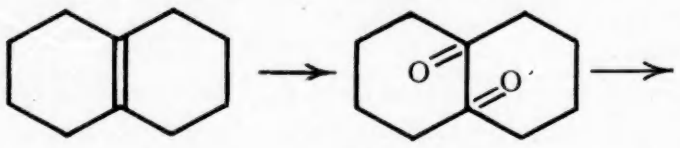
V II

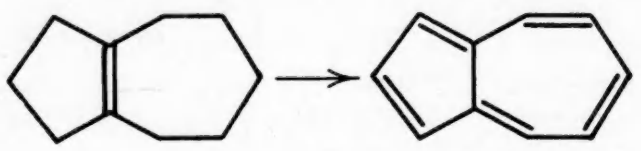


VI I

These structures rest on the additional assumption that the naphthalene hydrocarbons I and II were formed by the indicated rearrangements, which may be considered as analogous to a retropinacolone rearrangement. Preliminary confirmation for the azulene ring system was obtained through synthesis.

The first syntheses of azulenes were accomplished by Pfau and Plattner from octalin; this was ozonized and the resulting diketone was cyclized to a bicyclic ketone which was then converted to a carbinol by a Grignard reagent. Dehydration and dehydrogenation gave simple azulenes, the side-chain R being determined by the Grignard reagent used.





A later synthesis started from substituted hydrindenes, the six-membered ring being widened by the use of diazoacetic ester. The most recent synthesis of the Bicyclo[5.3.0]decane (Azulene) ring system starts with cycloheptanone; the five-membered ring is built up on the seven-membered ring in several steps.

The compounds thus obtained had the deep blue color of the azulenes and formed similar derivatives. The synthetic vetivazulene was identical in all its properties and those of its derivatives with the natural product. The parent hydrocarbon, azulene, forms cobalt-blue crystals, m.p. 99° C., having an odor like the isomeric naphthalene.

References

Baker, J. Chem. Society (1945) p. 264.
Plattner, Helv. Chim. Acta *29*, p. 730 (1946).

The Preparation of Acetylenic Alcohols

By C. F. H. ALLEN*

DURING the last few years there has been considerable interest in acetylenic alcohols, which, by virtue of their great reactivity, are useful substances for chemical work. Though long known, their recent production on a plant scale has been made possible because of the advances in the technique of acetylenic chemistry.

Secondary and tertiary acetylenic carbinols are formed by the same general reaction, that of an organometallic compound of acetylene or one of its derivatives with an aldehyde or ketone.

*Research Laboratories, Eastman Kodak Company, Rochester 4, N. Y.

$$RC{\equiv}CM + R'CHO \longrightarrow RC{\equiv}CCHR'(OM) \xrightarrow{HX} RC{\equiv}CCHR'(OH)$$

$$RC{\equiv}CM + R'_2CO \longrightarrow RC{\equiv}CC(R')(OM)(R') \xrightarrow{HX} RC{\equiv}CC(R')(OH)(R')$$

The many variations in the procedures described are all aimed at bringing about this result. This reaction was discovered by John Ulric Nef, at the University of Chicago, in 1899.

Acetylene itself forms intermediates containing two atoms of metal, so that under suitable conditions it can be made to react with two molecules of a carbonyl compound, leading to diols.

$$MC{\equiv}CM + 2RCHO \longrightarrow RCHC(OM){\equiv}CCHR(OM) \xrightarrow{HX} RCHC(OH){\equiv}CCHR(OH)$$

The most useful organometallic compounds in the laboratory seem to be Grignard reagents, and, in the plant, sodium, potassium, or copper derivatives. Magnesium intermediates are formed in two steps. The first is the preparation of a cheap Grignard reagent, usually ethylmagnesium bromide, which is then decomposed by the acetylene, whereby the acidic hydrogen is replaced by the –MgBr residue.

$$RC{\equiv}CH + C_2H_5MgBr \longrightarrow RC{\equiv}CMgBr + C_2H_6$$

The sodium acetylides are not formed separately. The ketone is first treated with sodium amide and then acetylene is admitted as long as it is absorbed.

The potassium derivative could be prepared by a similar series of reactions, but the cheaper potassium hydroxide is much more advantageous to use. A most ingenious method for obtaining a finely divided suspension of potassium hydroxide has been patented recently. A mixture of an aqueous solution of the base, a little alcohol (e.g., butyl) and a high-boiling hydrocarbon (e.g., xylene), is heated at 140°C. The water is removed by azeotropic distillation. The mixture is then cooled with agitation to get fine particles, and acetylene is introduced, followed by the carbonyl compound. Since it has been stated that the alcohol is essential, it would appear that a potassium alkoxide is formed as a first step in the reaction, and that this subsequently reacts with the carbonyl compound.

The acetylenic carbinols may be dehydrated to enynes

$$CH_3C(CH_3)(OH)-C{\equiv}CH \longrightarrow CH_2{=}C(CH_3)-C{\equiv}CH + H_2O$$

or reduced to saturated carbinols.

$$HO{-}CH_2{-}C{\equiv}C{-}CH_2{-}OH \xrightarrow{[H]} HO(CH_2)_4OH$$

The 2-butyn-1,4-diol used in the last illustration is obtained by interaction of formaldehyde and acetylene, in the presence of copper acetylide and a bismuth salt, the latter inhibiting dehydration to cuprene.

New Eastman Organic Chemicals

P 5836	2-Amino-4-chlorotoluene (Practical) MP 20-22°	500 g.	$3.25 D
	$NH_2C_6H_3(CH_3)Cl$...MW 141.60		
P 5846	Benzylethyl m-toluidine (Practical) BP 168-172°/10 mm.	1 kg.	5.00 E
	$C_6H_5CH_2(C_2H_5)NC_6H_4CH_3$...MW 225.32		
P 5776	Dihydropyran (Practical) BP 84-86°	500 g.	7.00 D
	$OCH{:}CHCH_2CH_2CH_2$...MW 84.11		